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DESIGN AND DEVELOPMENT OF WIRELESS OPERATED LOW COST PROSTHETIC HAND BY FUSED DEPOSITION MODELING

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ABSTRACT

In present days, unfortunately, many of the people were losing their hands in different situations. The human body parts, which replaced by the artificial parts are known as prosthetic parts. Recently, the advent of 3D printers has enabled people to produce many inexpensive and obtainable prosthetics. This 3D printing technology is used because it takes less cost and manufacturing of hand should be accurate as per the design. In the present project, a low- cost wireless operated prosthetic hand developed with the help of fused deposition modeling. To validate the performance of the developmental prosthetic hand the No.of trial and error experiments conducted. The prototype was agreed some results and some experiments show the mixed results. The overall weight of the prosthetics is optimized and giving the desired functions at a t lowest weight than the normal bionics

KEYWORDS: Prosthetics, Fused Deposition Modelling & 3D Printing

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Original Article

INTRODUCTION

Due to the increase in the vehicles on the roads carried in heavy traffic situations, some will leadaccidents can occur to anyone, there may be accidents occurs to the pedestrians and some vehicle accidents can also be occur this leads to serious injury will lead to loss of the organics also. Losing the organisms and replacing them with the traditional methods will be a huge cost that may be not possible to invest in everyone. The development of the traditional methods will lead to huge time. Nowadays, almost all the medical companies are also providing very good solutions like prosthetics for the patients who may lose any parts when they met with accidents unfortunately. Most of all the prosthetics are giving better performance, having the good aesthetics, and having the movement range in the constrained path. Most of the prosthetics are a replica of the human hand and having the movement as if human fingers and that condition that condition causes them to move. The good thing in the 3D printed prosthetics is it includes less cost as compared with the normal transparencies and this does not require any surgery. However, the attaching of the prosthetics to the human body requires higher-end supervision of the patient for the proper implantation of the prosthetics ,However, prosthetics that include good functions or having better performance prove more expensive and proven overall cost even more. Some prosthetics may go cost up to thousands of Rupees, this cost alone only for prosthetics alone not including the doctors fee. Prosthetics handle provides the betterfacility for patients with the ability to pick and place the simple objects, typing on the keyboard and some simple day-to-day operations.

Since the inception of the 3D printing, maximum all the medical distinguishes and technical researchers are trying to set up a database on the prosthetics development with the additive manufacturing. Researchers are

designing and developing the new prosthetics that can be easily suitable for the human arm. Most of the research papers published in the field of 3D printed prostheses [1-7]. Some scientific websites are also providing the free resources regarding the design and development of the prostheses. Innovis the website proving the free source code for the developing the prosthesis. This 3D printing community has grown into a worldwide movement of tinkerers, engineers, 3D-printing enthusiasts, occupational therapists, university professors, designers, parents, families, artists, students, teachers and people who have developed 3D-printed prostheses. [9] Investigated that the development of the prosthetic hand, which is operated by power, is ranging from the Rs 50000 -100000. Resnik L, et al [10] stated that the revolutions of the development of the rapid prototyping made prosthetics would be more useful for the who will not accommodate an expenditure of the readily available prosthesis robot hand.

ADDITIVE MANUFACTURING

3D printing is an additive manufacturing technique is the part of the Rapid prototyping technology. Products developed in the 3D printing are layered by layer instead of removing material from a large piece of material like the traditional manufacturing process. Example machining process in the CNC milling.

3D printing has several advantages compared with traditional manufacturing techniques [11, 12].

- It is possible to make products with one part; therefore, no assembly is required.
- There is flexibility in the design; therefore, highly complex geometries can make easily.
- Designs can easily be personalized and customized according to the customer requirements; there is no need to alter the machine and tools like traditional machine.
- Parts can produced from idea stage to prototype stage in the less span of time; which gives the best advantage of rapid design improvements.

3D printing has also some disadvantages compared to other manufacturing techniques [13, 14].

- It is tough to predict the mechanical properties of printed parts. The resulting output strength of a party is dependent on the fabrication method, and various parameters like density, thickness can select depending on the printing orientation.
- The accuracy is affected by material shrinkage in the part, different machine parameters and errors induced by the software as well as post processing of the parts.
- The size of an object limited by the size of the printer indicated by building volume. Very large objects cannot be printed with present 3D-printing technology.
- 3D-printers work with only a limited amount of materials compared with conventional manufacturing, which can work with nearly any material

Before going to print the objects can be designed by using the software's like AutoCAD, CATIA, PRO E, etc, and can be created by using scanning. These generated models can save in the form of. STL files. These. STL files can use for printing. There are different types of 3D printers like FDM, SLS, SLA SLM LOM etc. In the current project, FDM used, ABS material used for this project based on its properties.

PROSTHETICS

Prosthetics are having a long history from its beginning to the present and that leads to future to invent something new rather existing. While developing these prosthetics there were cross checked so many ideas and made inventions and expanded it to different sectors, as a result, fixed position foot is invented which is not comfortable for walking this leads to falling down some time so that the iron is being used in prosthetics. In 1500 BC, the invention of the computerized leg had started and made a great path for the manufacturing of prosthetics. This has become very useful for fitting and manufacturing of permanent prosthetic devices. In these modern days as a result US civil war, based on the amputations. Americans are forced into the prosthetics. James Haryer is the first amputee that had developed and patented that has Haryer limb. All this leads to the formation of association, i.e. American orthotic and prosthetic association (AOPA). As based on some drawbacks, which present in this prosthesis, these cause vast changes in the manufacturing of prosthesis i.e. to implementing of using lightweight materials, microprocessors, patient modeled devices, some chips, robotic devices to make comfortable in the daily life. As a result, nowadays a new technology is helping in their manufacturing prosthetic, that it generates fewer weight components, at low cost and comfortable for fixing or fitting to the body.

DESIGN AND DEVELOPMENT OF LOW COST PROSTHETICS HAND

By considering the drawbacks in the existing literature models, a new model of prosthetic hand designed to overcome the drawbacks. Here the main intention is to satisfy the minimum requirements of human needs. This mainly works with the help of servomotor and nylon string with wireless operation. The input data extracted from the patients with ECG, another way of taking input is measuring the dimensions whomsoever required. Very first, this prosthetic hand (Figure 1) should designed in Pro/E GUI and printed in FDM. Three-dimensional design of the prosthetic hand components was performed with the commercially available design software's like Pro/E software. The thumb, middle and ring fingers are made of the tip segment and the middle one is made of base segment. The pinky fingers are made up of a tip segment, which is connected to the palm of the hand. The thumb consist of just two segments and sits on the above platform away from the palm; permit it directly to oppose the other fingers when touched.

Development of Prosthetic Hand

Upon completion of virtual mechanical simulations, the hand was ready for manufacture. The method of manufacture selected was rapid prototyping on a Fused Deposition Modelling (FDM) 3D printer. Fused Deposition Modelling, also known as Fused Filament Fabrication is a type of additive manufacturing where a thread of molten plastic used to trace out a layer of a part in the X-Y plane. Once an entire layer traced, the print platform lowered and the next layer is printed.

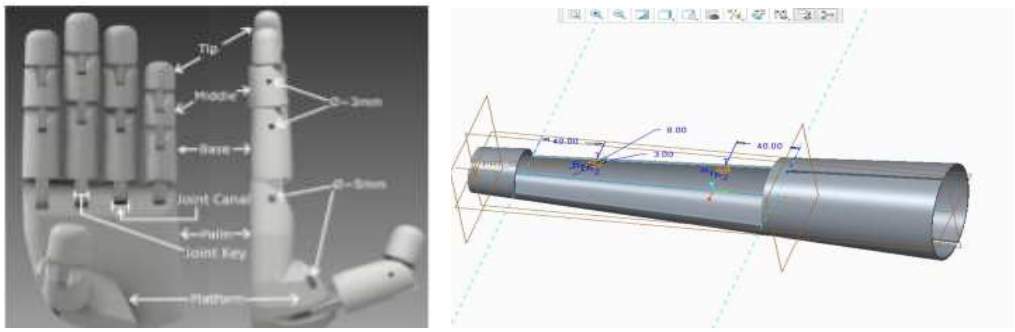


Figure 1: Prosthetic Hand Design

The prototype hand model converted into stereolithography (STL) files in Pro/E. These STL files were loaded into the printer's software, arranged for printing, and converted to G code. G code is the control code that provides the printer with instructions regarding the velocity of the print head, extruder temperature ,and the filament (PLA) extrusion velocity. The printing time taken more than 20 Hrs, after successful completion of printing the prosthetic hand model is equipped with the necessary electronics for smooth functioning. Figure 2 shows the complete developed model with the electronics.

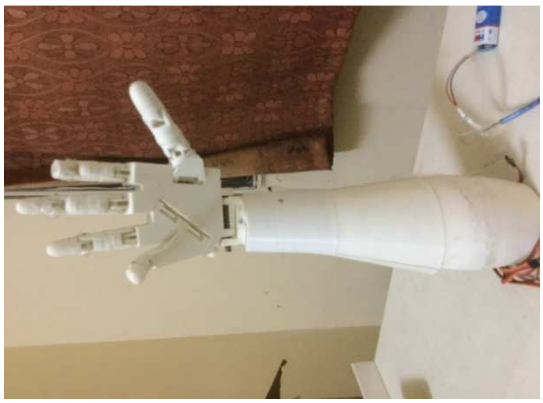
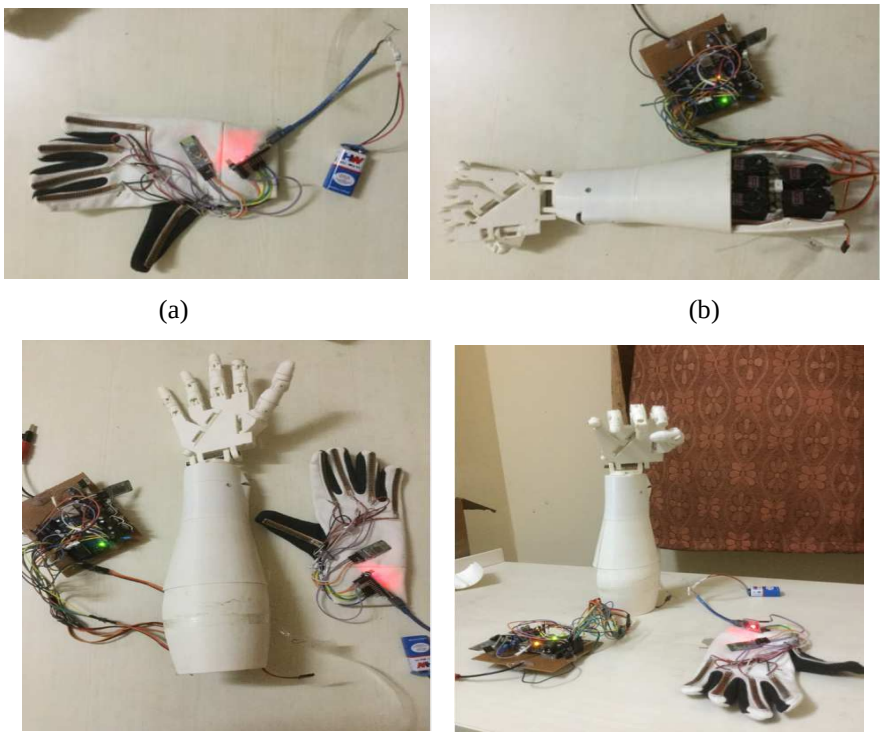


Figure 2: 3D Printed Prosthetic Hand

From the literature, it observed that previous developed prosthetic hands designed and printed with FDM machined and operated by mechanically patients. In this research projects authors contributed for the development of wireless operated prosthetic hand, the gloves equipped with the sensors attached and given the necessary frequency range from conducting the No.of experiments. The complete arrangement shown in the Figure3.



(a) (b)

(c) (d)

Figure 3: a) Glove Attached With Sensors b) Prosthetic Hand Equipped With Electronic c, d) Integrated Assembly of Glove With Prosthetic Hand Operation

PERFORMANCE CHARACTERISTICS

A series of tasks conducted on the group of persons. The group comprised of adults and children's males and females having the lack of hand. An experiment was conducted on the No.of times some of the results shows successful and some are showing unsuccessfully and some results shows the mixed results. When the group of panel asked for participants to do cutting food, a group of members indicated that some food cutting is difficult like the hard things and some things are a cutter, very good manner. In some other cases, the participants are unable to hold the scissor at all. Other group members are unable to hold that also. Some participants are not able to hold the knife because of the grip between the tool and thehand. Some age people can able to cut the objects very tight and able to cut the objects with the help of the knife. Some other experiments were conducted on the different people to open and close the simple screwed objects, it shows the mixed results. The screwed objects consist of opening and closing of the jar lid. Group of members consists panel were open the jar in two cases.

- The jar with lid will not be screwed on too tightly, and
- The pointer finger and thumb finger were used to twist the jar lid rather than the total amount of the hand. Although the smooth surfaces of the jar did not affect the grip of the prosthetic hand, the group of members had very difficult in holding the jug. The water pouring from the jug with the prosthetic hand is not giving theta much better results. This difficulty may be due to additional weight added on to the prosthetic arm will severe this condition.

CONCLUSIONS

The present work provides the detailed procedure design, development of FDM based prosthetic hand. Operated wirelessly and consists of six servo motors (5 motors for five-finger actuation and 1 motor for wrist rotation) where the movement of fingers controlled by integrating glove with five flex sensors. The prototype is composed of five fingers, with a total of 16 degrees of freedom distributed in two thumb joints and three more rotation joints for each of the other 4 fingers. Despite having a unique gripping system, it is equipped with a cable compensation system that allows better adaptation of the hand when dealing with irregular objects. The main features of the prosthesis are its anatomical shape, resting position close to a natural one, forearm length adjustment system and low weight. The structural part of the prototype made by Additive Manufacturing in a 3D printer. The filaments used were PLA (polylactic acid) which, besides having considerable mechanical resistance and a good finish and appearance, is biodegradable. All the parts in prototype ,including Arduino, servo motor, battery, Velcro straps, wires and other connections do not exceed 750 grams. This is an interesting weight, considering that according to specialized literature, the forearm/handset is equal to a value between 2.3 and 2.9% of the body mass. For example, a person of 70 kg has a forearm + handset the weight of between 1610 and 2030 grams. This puts the prosthesis on an interesting level. New improvements have been made to the prosthesis, especially the operation of hand through wireless mode as well as regarding the determination of the mechanical resistance of the PLA, used in the 3D Printer. And in the insertion of force sensors at the fingertips, which will allow better control of the grip, allowing for the adjustment of the force and speed used in the servo motor, in order to differentiate heavy and robust objects from other light and fragile ones.

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